Appendix C - Concept of TRT

Introduction

This appendix covers explanations and figures of the tree running tool (TRT) concept. The appendix is divided into two chapters, were the first one gives a general description of the tool, while the second provides explanations of some design details and the intentions regarding them. Figure 1 shows the TRT mounted to a XT, with an ROV closing up to the tool.

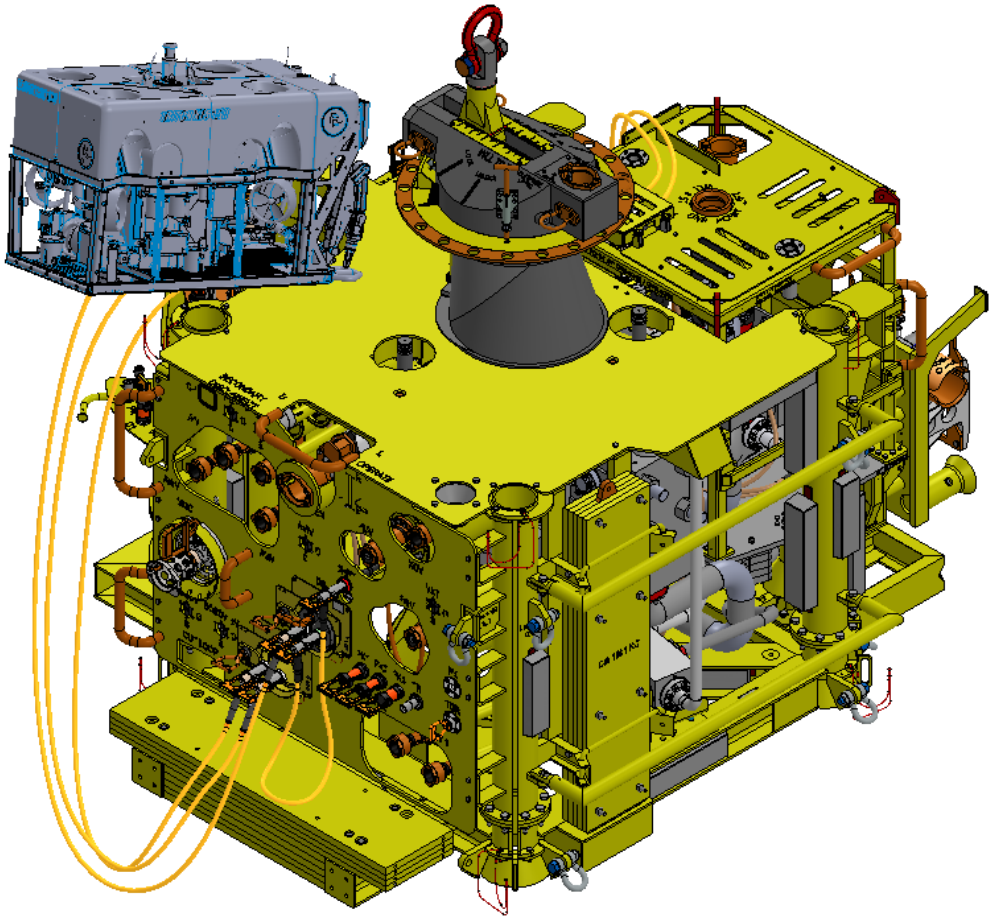


Figure 1: The TRT mounted to the Dvalin 7x5 HXT.

Note: The counterweights are still on the XT and should not have been there.

The TRT concept is based on the design basis, referring to appendix A. The design basis shows both a mechanical TRT and a hydraulic TRT. A decision was made to develop av mechanical TRT. This is due to the lack of time, as developing a hydraulic TRT is more time consuming. The decision would then give Aker Solutions a more detailed concept which they can continue developing if they find the solution interesting.

The TRT design design is inspired by the XTHT, referring to the main report. The TRT has many similarities, and because of this, the appendix only covers the characteristics of the TRT. The following list covers which features and components that is similar:

- **Features**
  - Locking mechanism
  - Anti-rotation
- **Other Components**
  - Main body
  - End cap

The structural geometry of both tools is basically equal, beside some small modifications at the lifting lug and the funnel, which is clearly shown in the appendix's figures . These modification is assumed to not affect the structural integrity of the TRT. Therefore, would the calculation report of the XTHT be a very good estimate to prove the TRT's lifting capacity. Referring to appendix D for XTHT's calculation report.

1 General explanation of the TRT

The TRT is a subsea running tool used to land or retrieve the XT onto or from the wellhead. This TRT has a distinctive function as it enables multiple lifting configurations. The tool has an adjustable lifting point, with the intention to locate the point of attack above center of gravity, as Figure 2 shows. Thereby, the need of counterweights is eliminated. The tool can lift the XT in the following configurations:

- Complete XT
- Without FCM
- Without SCM
- XT only
- Tool only

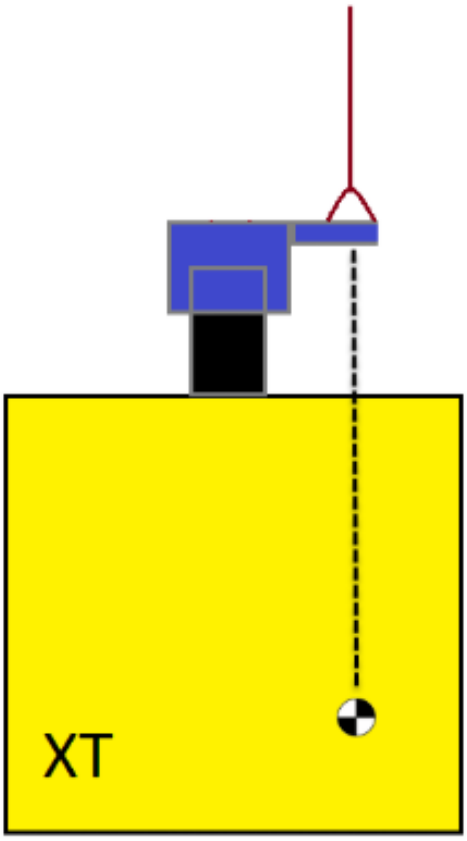


Figure 2: Point of attack position above COG

Figures 3,4,5 and 6 shows the concept of the TRT, while Figure 7 gives a section view of the tool. The next chapter reflects the TRT's characteristics.

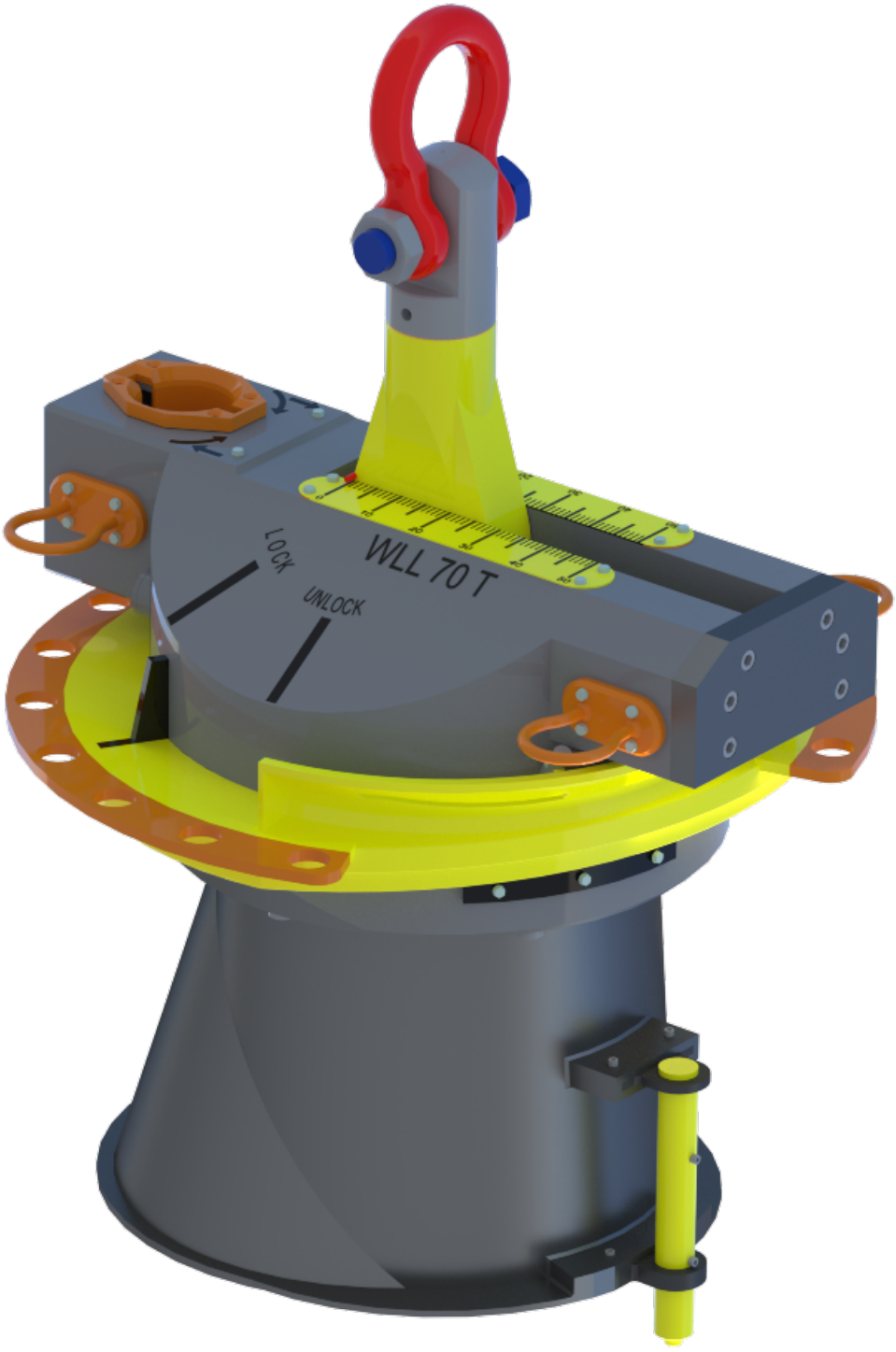


Figure 3: The TRT concept, first view

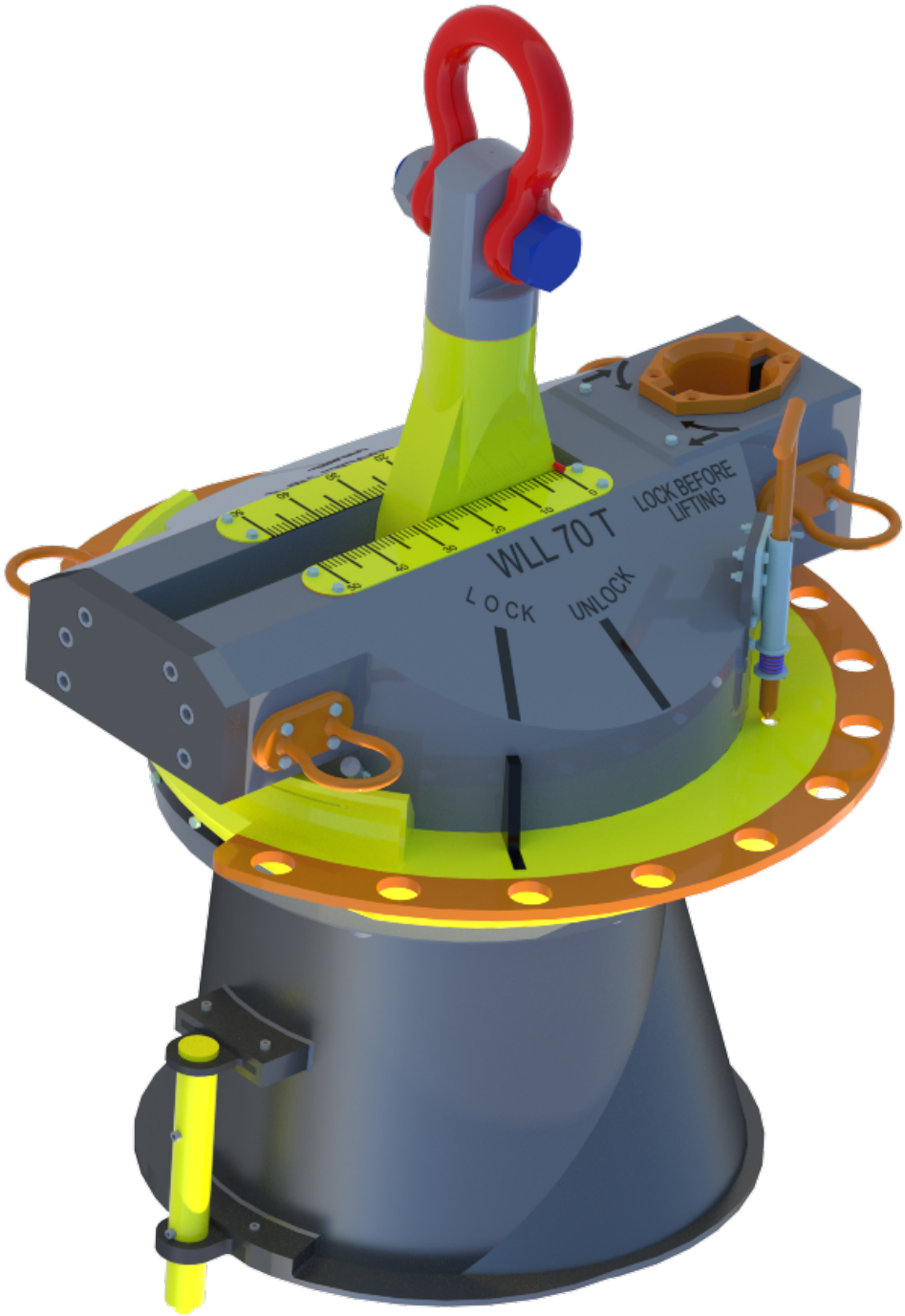


Figure 4: The TRT concept, first view

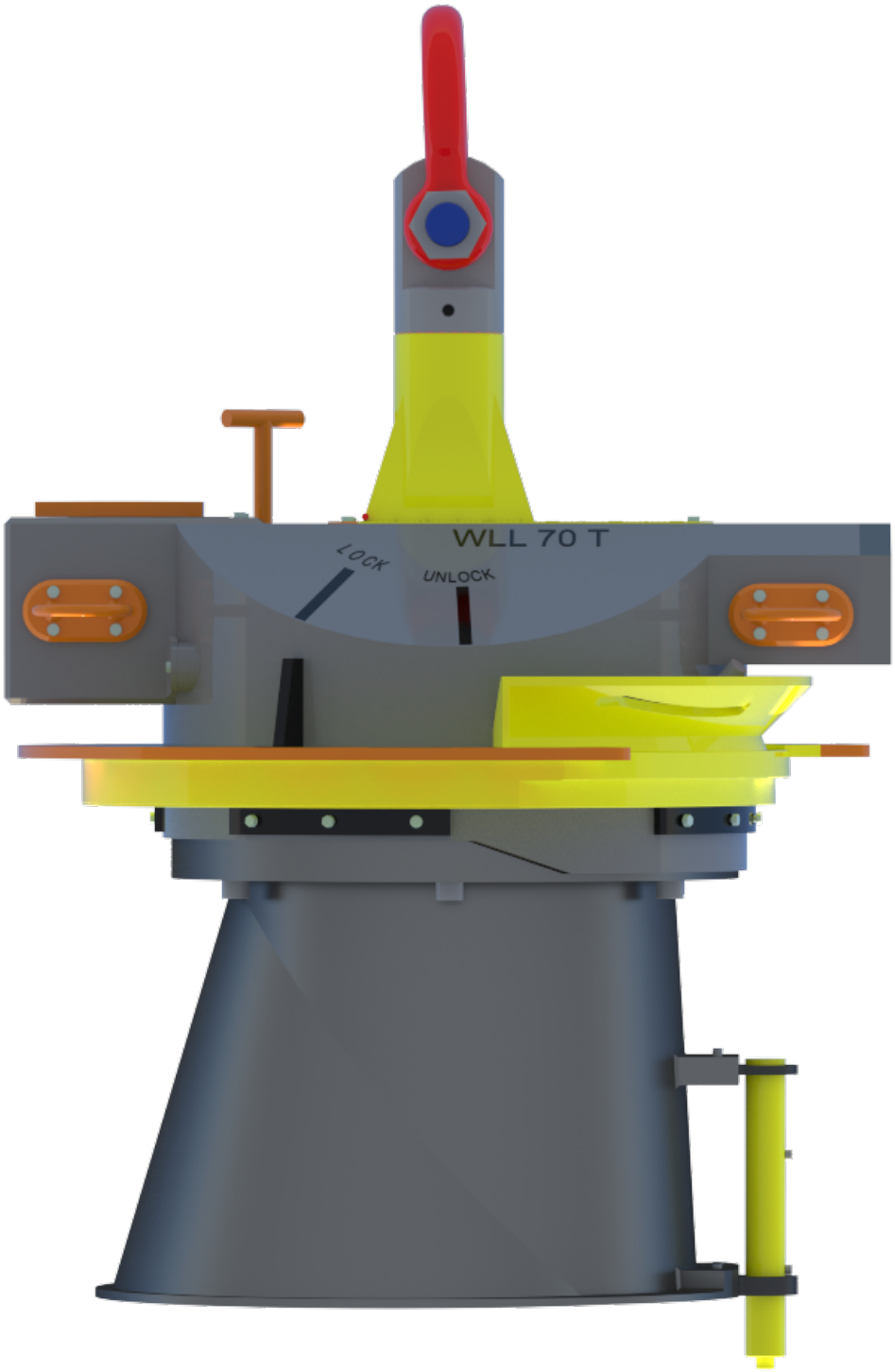


Figure 5: The TRT concept, first side view

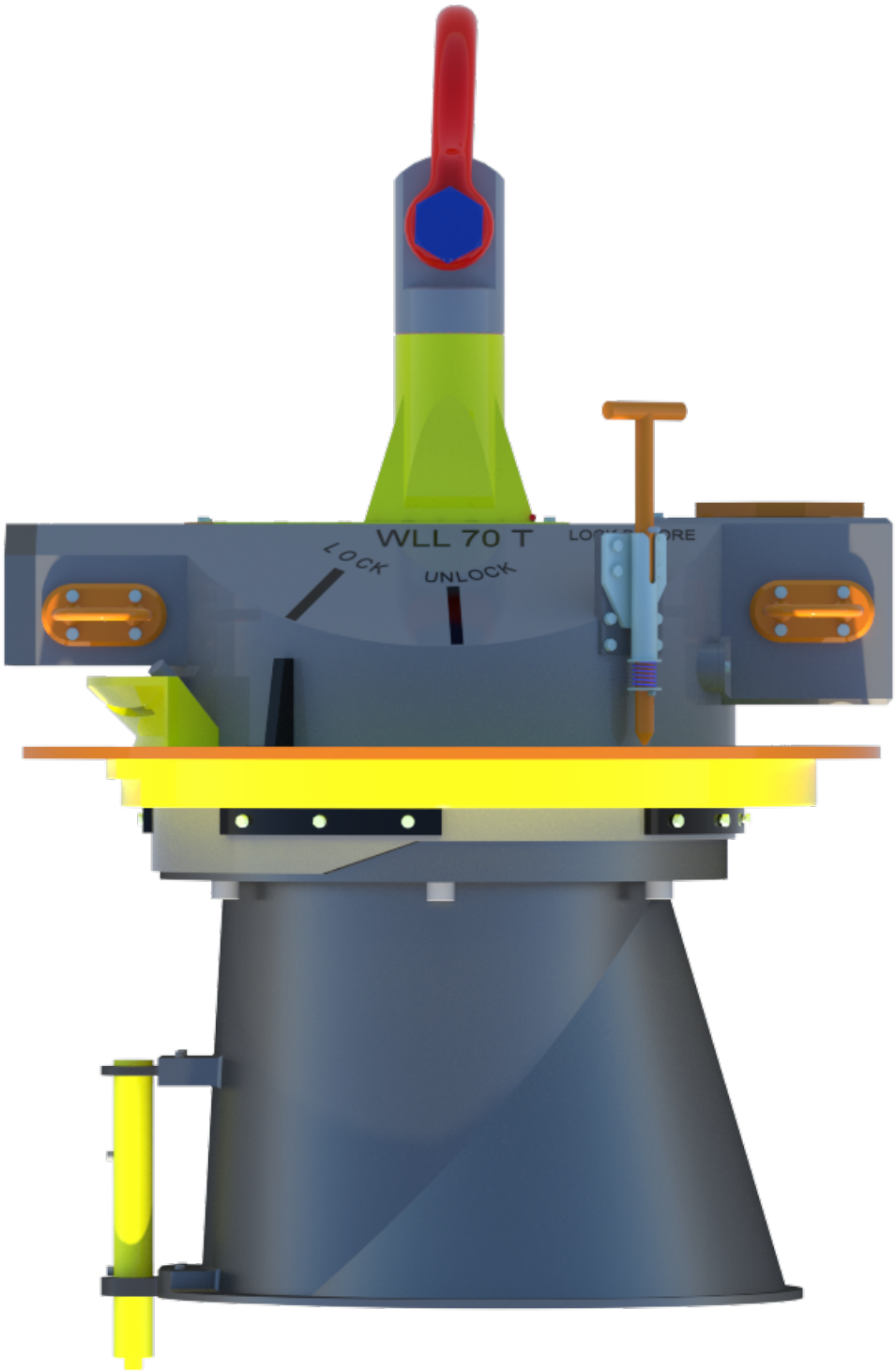


Figure 6: The TRT concept, second side view

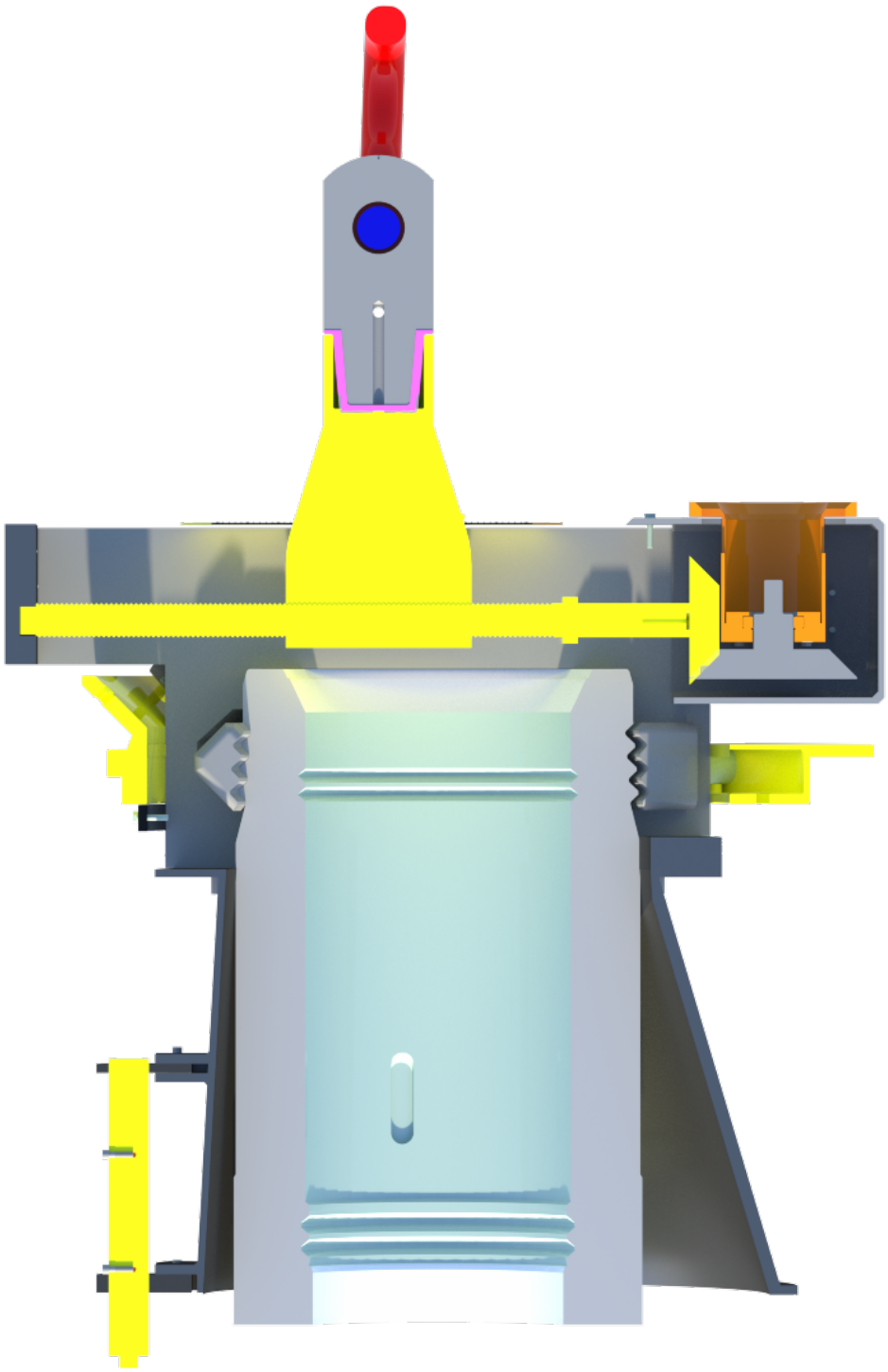


Figure 7: The TRT concept, section view.

Note: Figure 7 may be a bit misleading, like the locking dogs is not properly engaged. This is due to some difficulties that occurred in the Software when this section view was taken.

2 TRT's characteristics

This chapter covers design explanations and intentions on the TRT's characteristics.

2.0.1 Remotely operated vehicle

A Remotely operated vehicle (ROV) operates the TRT during subsea installation or retrieval of the XT. Due to this, many of the TRT's characteristics is based on having a proper and clear interface for the ROV.

The following points describe two important criteria that were decisive for the design:

- **Clearly visible ROV interface**
  All of the parts which the ROV is going to operate, needs to have a clear indication that they are intended the ROV. Therefore, all such parts are painted with a clearly visible orange color. This results in a reduced risk of any failure and ease the operation for the ROV.
- **ROV access**
  The ROV is only guaranteed access to the TRT in the same plane as the ROV panel or from above. Due to the TRT's different lifting configurations, this need to be taken into account.

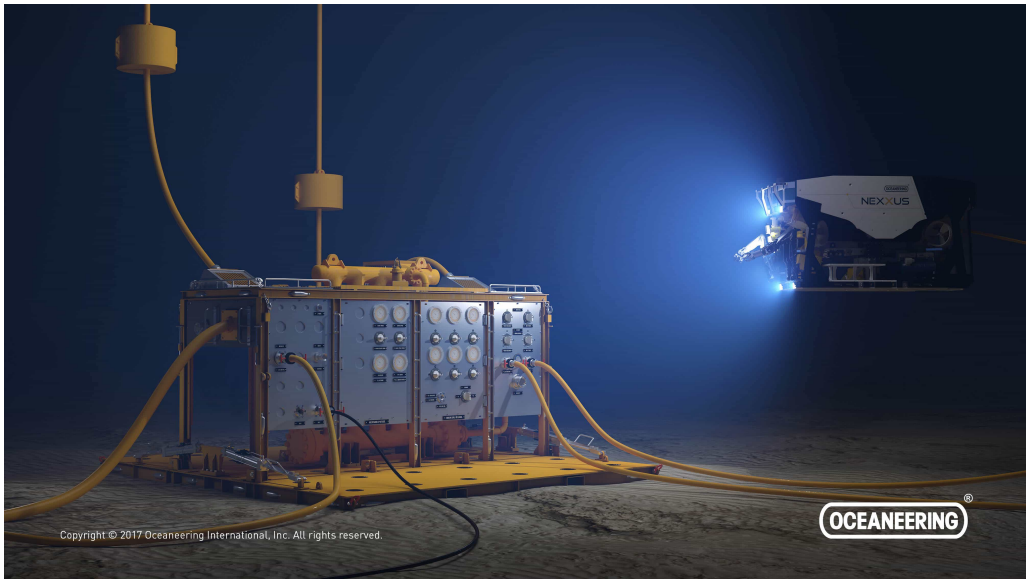
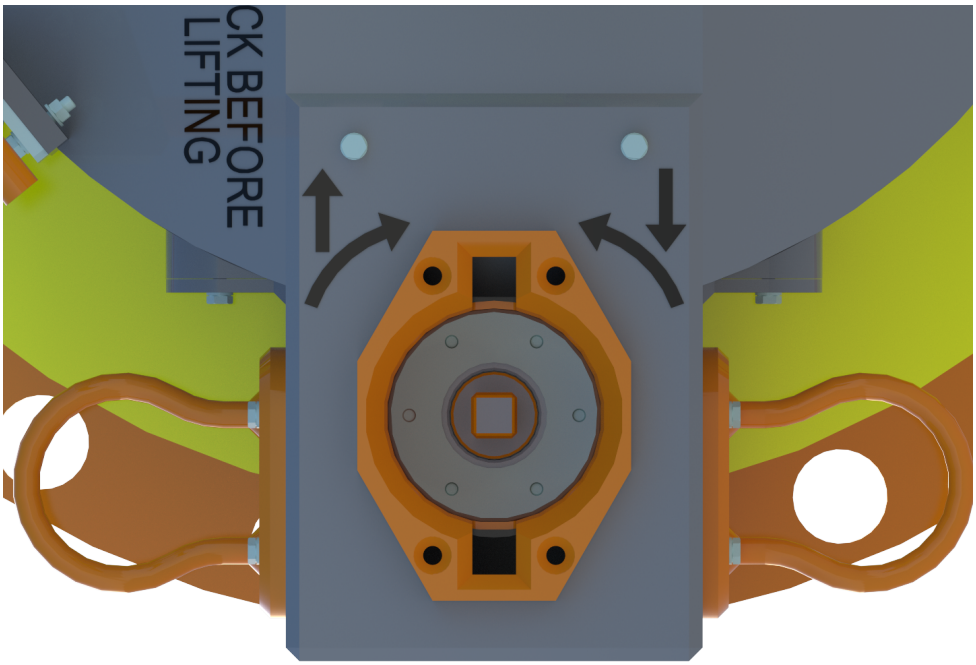


Figure 8: A ROV closing up to a subsea installation (Source: https://www.oceaneering.com)

2.1 ROV torque bucket

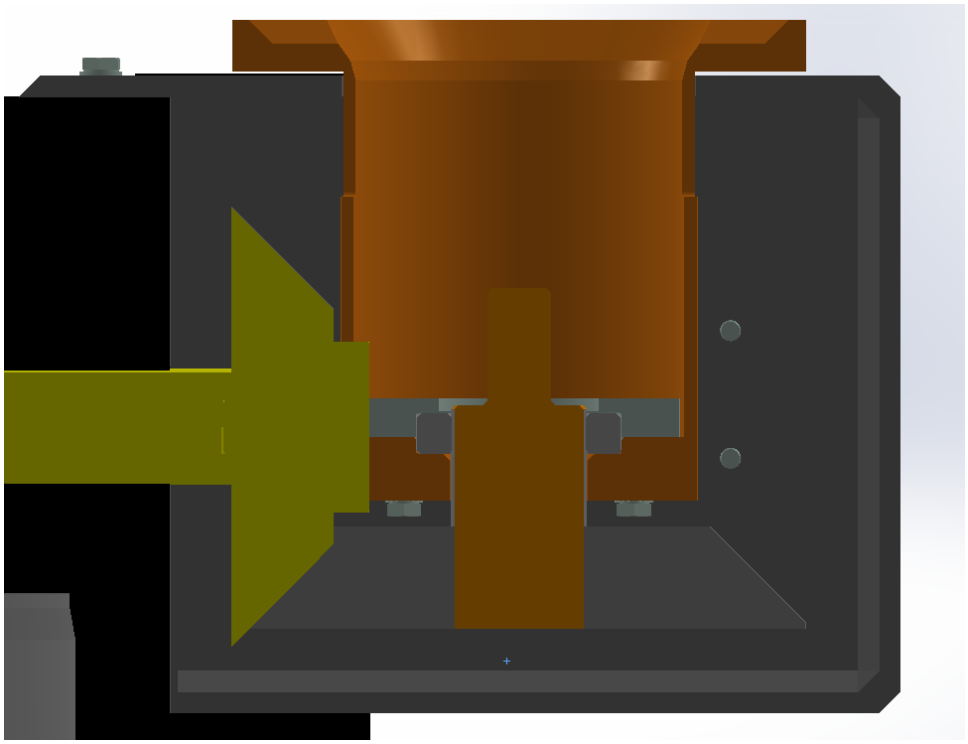
Figure shows the ROV torque bucket, which enables the ROV to move the lifting lug to its desired position by its hydraulic torque tool. The bucket is placed at the top, thus the ROV is guaranteed access. The arrows next to the torque bucket describes the lifting lugs movement due to the torque tools rotation. The rotation is transferred through a bevel gear and results in translation of the lifting lug, as shown in figure. The figure also shows that the gear has a ratio, which intends to increase the movement of the lifting lug. The rule verifies the off center distance of the lifting point.



(a) Torque bucket

Note: The ROV torque bucket is an existing component used by Aker Solutions, with the following identity: DIR-10000238352

(b) The lifting lug and the ruler. *Note: The tools own COG position is missing on the ruler*



(c) The gear

Figure 9: ROV torque bucket and its interfaces

2.2 Locking ring

Figure 10 shows the locking ring. The locking ring is equipped with several holes, which represent ROV handles. The high quantity is due to the ROV access described in the section 2.0.1. The locking ring also has a small hole which the secondary lock pin penetrates into, which is further described in the next section. Except from these two details, the locking ring is similar to the one at the XTHT. The black bracket aligns with the strips at the main body to indicate locked or unlocked position. Figure 11 shows the locking sequence.

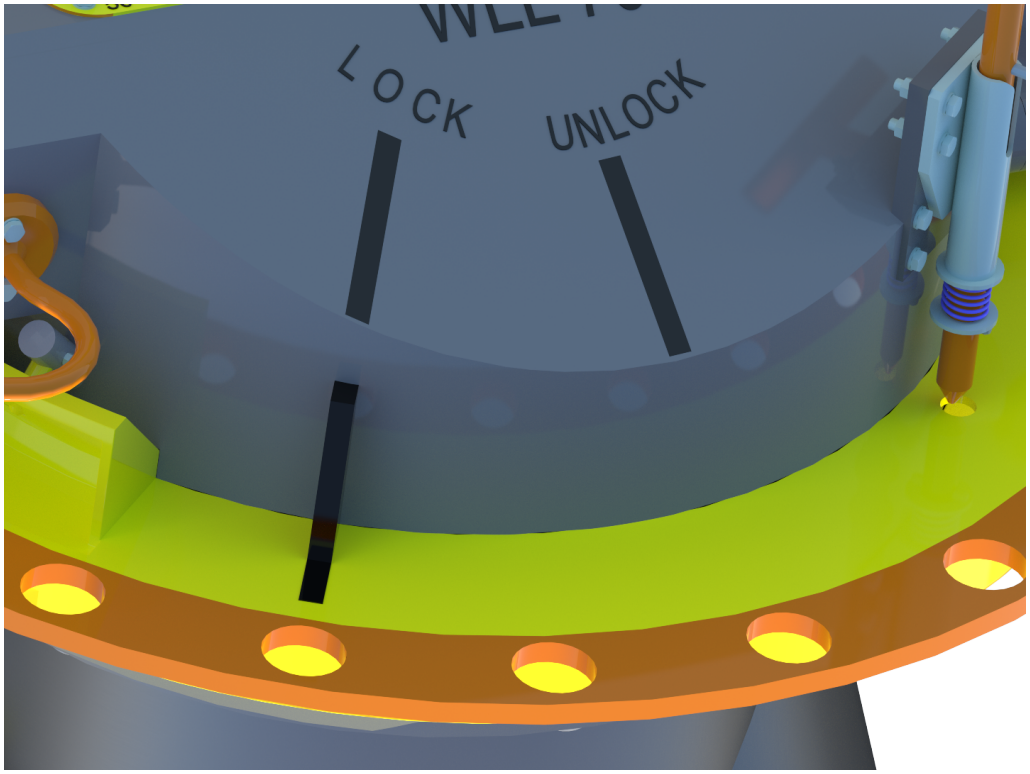
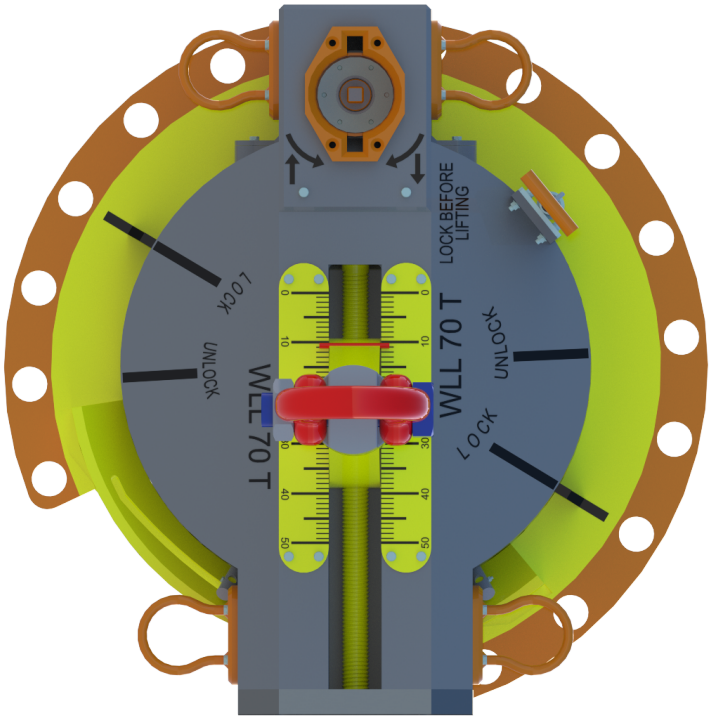
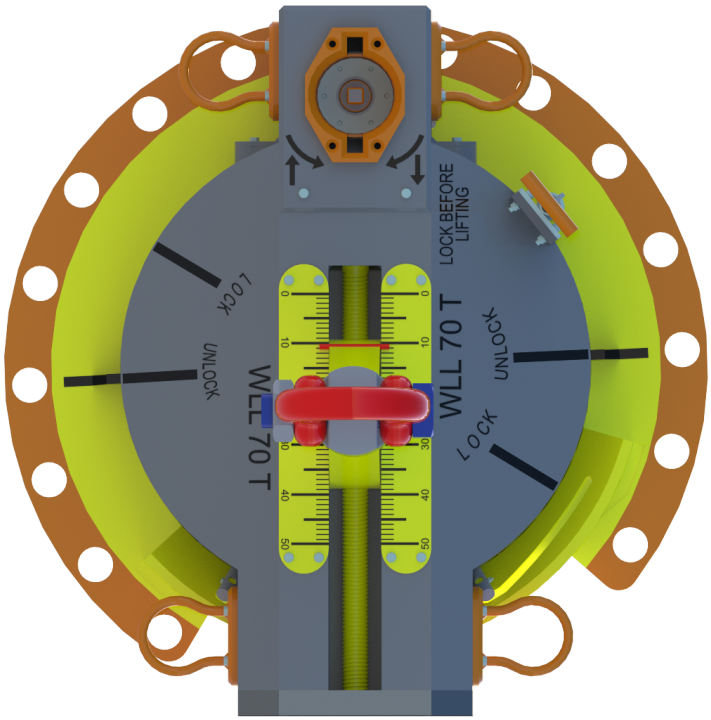


Figure 10: Locking ring with ROV handles and the small hole which interface the secondary locking pin.



(a) Lock



(b) Unlock

Figure 11: Locking sequence

2.3 Secondary locking pin

The secondary locking pin is shown in Figure 12s used as a secondary lock function, ensuring the tool to not detach from the XT. Note the text shown in the figure, reminding the operator to lock the pin before lifting. The pin is an existing component used on today's TRT, with identity: Material number - 10038167.

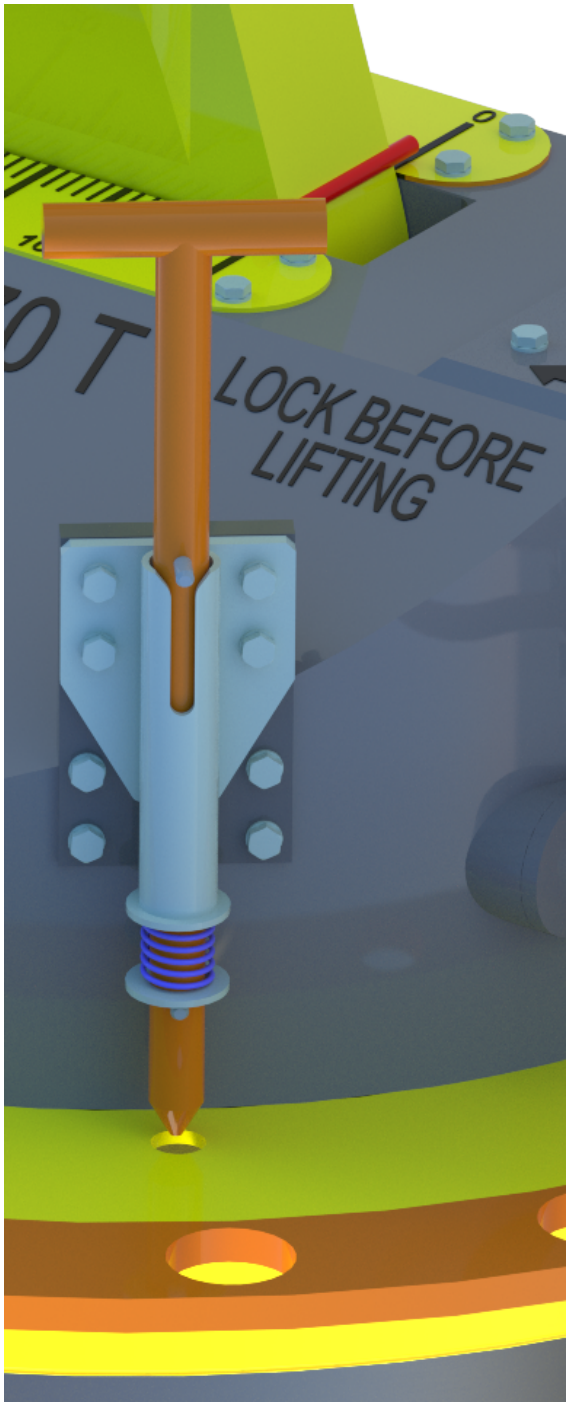


Figure 12: Secondary lock pin

2.4 ROV handles

One of the ROV handles is shown in Figure 13. These is located at four places at the tool and is necessary as the ROV needs support as it operates. If the ROV does not have support as it operates the lock ring, it would probably displace itself in the seawater.

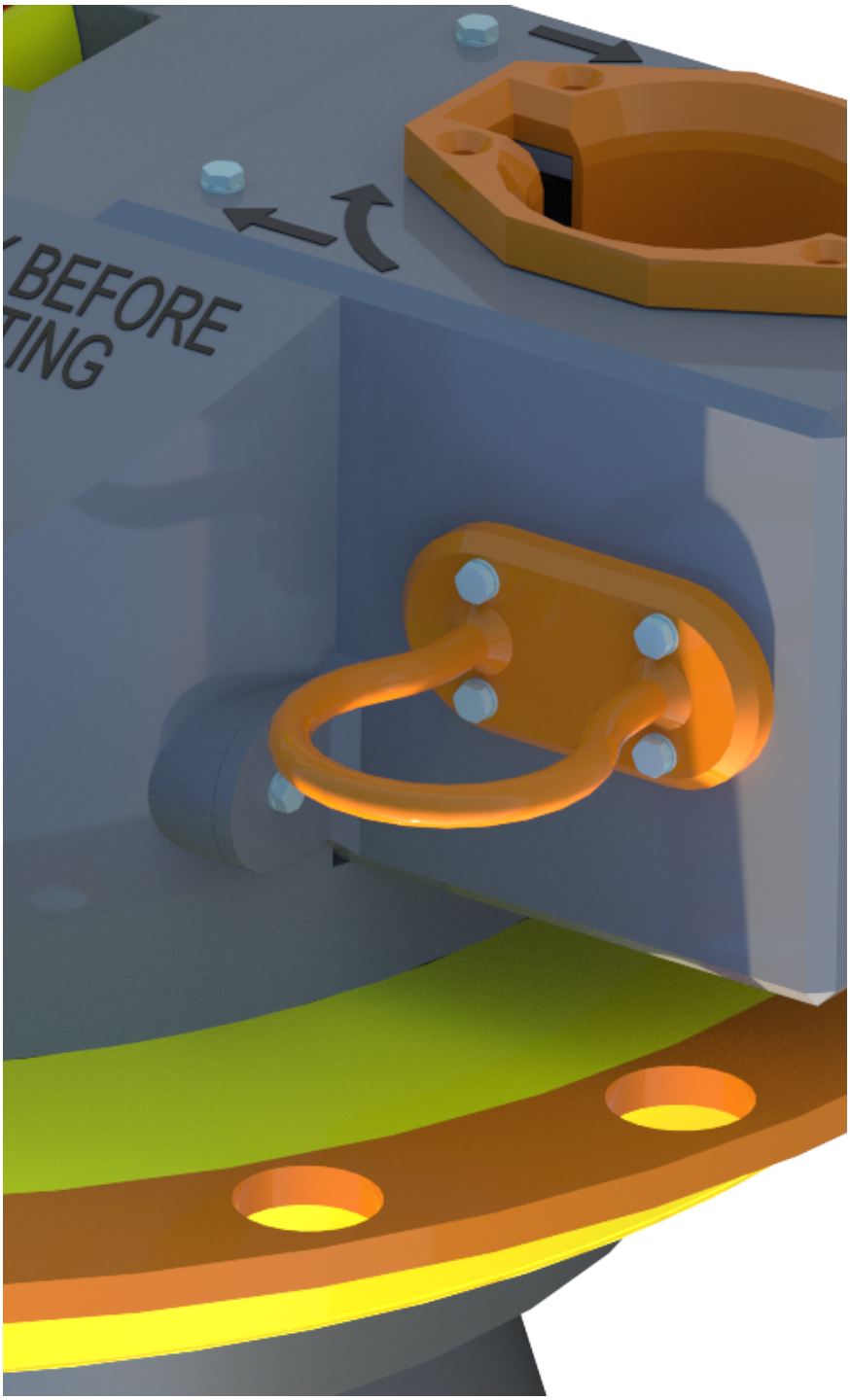


Figure 13: ROV handle

2.5 Funnel

The funnel and the tool connected to the spool is shown in Figure 14 and is magnified compared to the funnel at the XTHT. This is done with an intention to create better guiding properties for the tool. During XT retrieval at large ocean depths, it could be difficulties of entering the spool. The enlarged and conical funnel will make this operation easier.

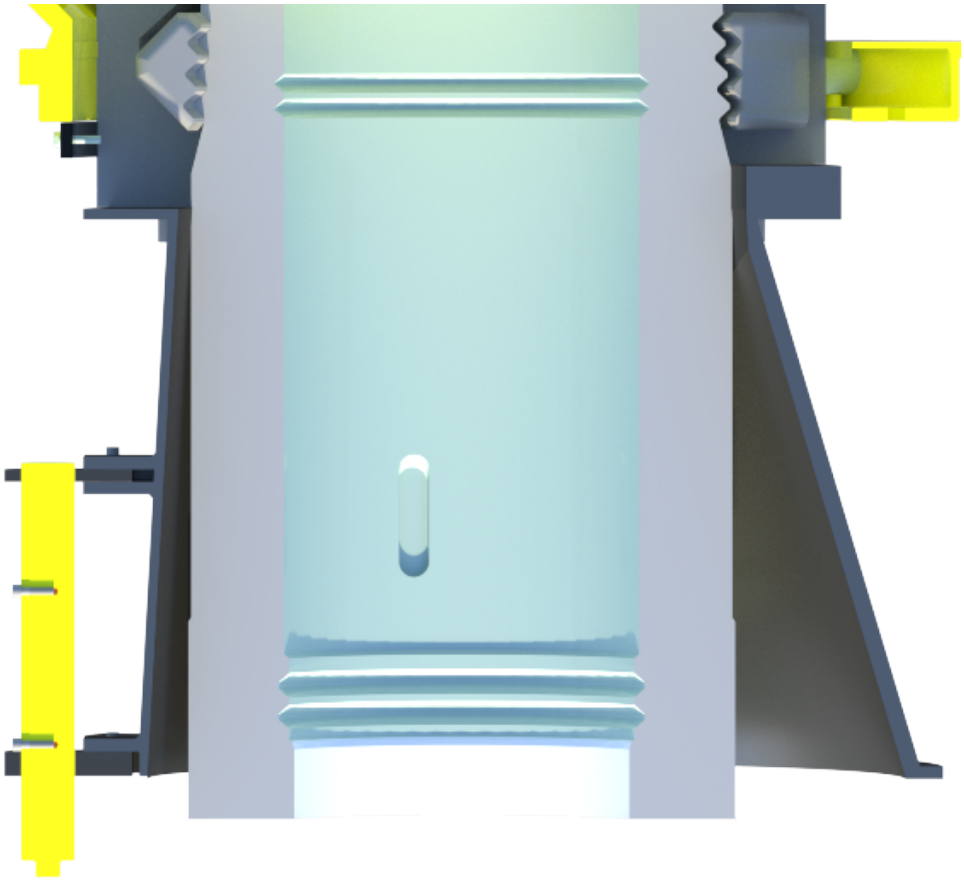
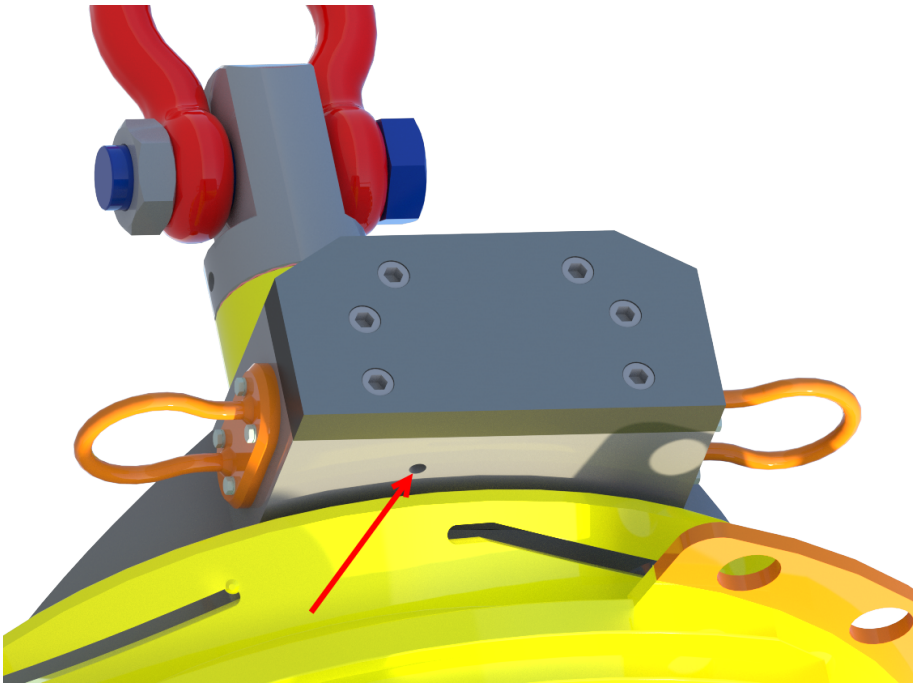


Figure 14: Funnel with greater guiding properties at the right side

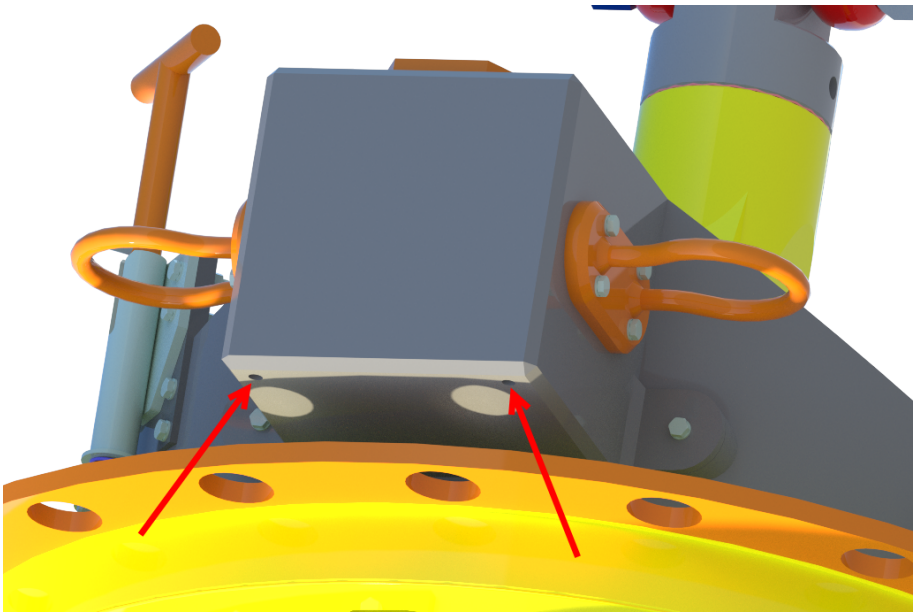
Note: Due to the need of a fixed anti-rotation pin position, the funnel is not enlarged at this. See the main report for further details.

2.6 Drain holes

Figure 15 shows drain holes located at different places at the tool. This is necessary to avoid seawater being trapped and causing unnecessary corrosion to the tool.



(a) Drain hole underneath the cantilever

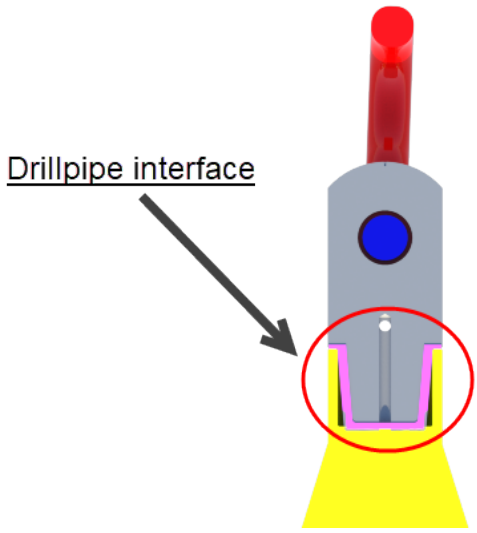


(b) Drain hole underneath torque bucket assembly

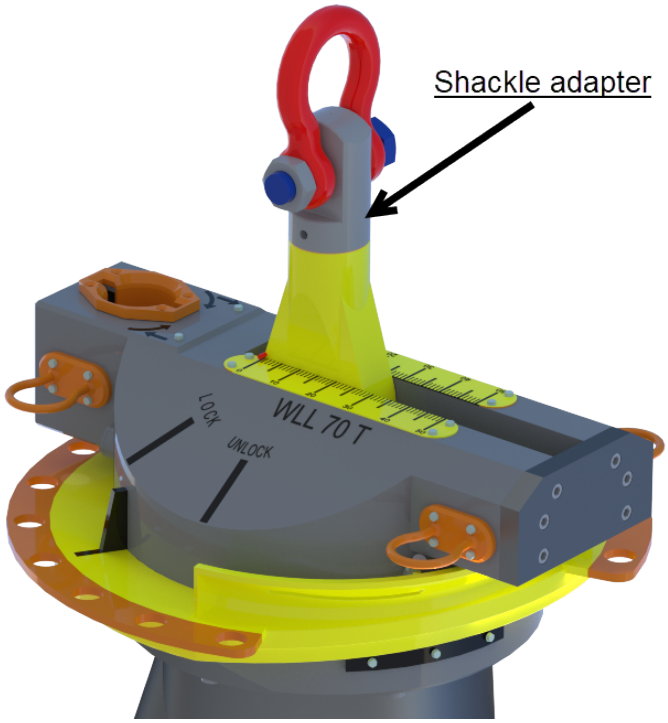
Figure 15: Drain holes

2.7 Drill pipe interface

As the design basis states, the TRT and XT could be lifted with drillpipe, referring to appendix A. Therefore, such an interface needs to present. The interface is female drillpipe threads located at the top of the lifting lug, as shown in Figure 16a. Figure 16b shows the shackle adapter which is screwed into the lifting lug and thereby enables lifting with a crane.



(a) Drillpipe interface, with female threads in lifting lug



(b) Shackle adapter

Figure 16: Drillpipe interface and shackle adapter

The adapter is taken from today's TRT, with identity: Material number - 10038167.